

Influence of nitrogen and weather conditions on the grain quality of winter triticale

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Abstract. The protein content and falling numbers of five winter triticale cultivars were tested in very different weather conditions (1998/1999–2000/2001) on *Stagnic Luvisol* soils (WRB classification) in the experimental fields of the Department of Field Crop Husbandry of the Estonian Agricultural University near Tartu (58°23'N, 26°44'E). All cultivars were fertilised with nitrogen fertiliser (NH₄NO₃) in early spring, using a norm of 0–200 kg N ha⁻¹ (increasing the amounts of fertiliser by 20 kg ha⁻¹). Fertilising with nitrogen after hibernation at the tillering stage in early spring increased the protein content of seeds averaged over years and cultivars by up to 1.57% in dry matter. Protein levels depended most on the cultivar, less on the weather conditions of the growth year and least on the nitrogen fertiliser (the determination indices of a dispersion analysis were 0.35, 0.32 and 0.14, respectively). The yield and protein content were in negative correlation ($r = 0,92^*$). Due to very different weather conditions during the growth period, the figures of the falling number were very different in different years.

Key words: winter triticale cultivars, nitrogen, weather conditions, protein content, falling number

INTRODUCTION

The independence of Estonia and its transition to market economy have brought about a significant decrease in sown areas and in the total production of crops in the past decade (Table 1). This has caused a need to find new high-yield and nutritious crops suitable for the local climatic zone. Therefore, a crop called winter triticale, known for its good yield potential and amino acid composition, started to be spread. The growing of triticale worldwide has shown that it has the yield potential of wheat and the adaptability of rye (Varughese et al., 1996).

Table 1. Sown area of field crops (thousand hectares)*.

Field crop	1990	2000	Decreasing, %
Cereals and legumes	397.1	333.2	16.1
Winter crops	87.1	50.6	41.9
Barley	263.7	165.1	37.4

* Statistical Office of Estonia, 2001.

Until this time barley has been the most important feed crop in our country, but winter triticale should be an acceptable alternative crop possessing considerable potential as a source of energy and protein. However, triticale is known as a crop with high α -amylase activity (McEwan & Haslemore, 1983; Branlard et al., 1985), and for this reason, getting high-quality grain in wet areas requires greater attention to avoid lodging by using the best sowing and N-fertiliser norms (Alaru et al., 2001) and a precise choice of harvesting time. The earlier flowering and later ripening (5%) of triticale, as compared with wheat, causes a longer seed-filling period (16%), which is a serious disadvantage in areas where the final period of plant growth is problematic (rains, late summer, etc.; Pfeiffer, 1994).

A suitable winter triticale cultivar that would tolerate the local unstable climate sufficiently well has not yet been found. Therefore, the aim of this research was to find a triticale cultivar which would be good for Estonian conditions. Some cultivars were sensitive to our wintercold (Lasko, Dagro), but mostly the initial opinion about winter triticale's lower winterproofness, compared to that of rye and winter wheat, has not been confirmed. However, it is difficult to find cultivars that would tolerate frequent rainy summers and resist pre-harvest sprouting. Only in very dry summers, the harvesting of the crop in its full ripeness has provided high-quality yield in this region. This article discusses the protein content and falling numbers of different winter triticale cultivars depending on the nitrogen fertiliser backgrounds in three years with very different weather conditions.

MATERIALS AND METHODS

The experiments were conducted at the Department of Field Crop Husbandry of the Estonian Agricultural University near Tartu (58°23'N, 26°44'E) on *Stagnic Luvisol* soils (WRB classification) from 1998/1999 to 2000/2001. Nine winter triticale cultivars were used in these experiments. This article considers five of them: Modus, Tewo, Vision, Lasko and Dagro. The area of the experimental plots was 10 m², the sowing rate was 400 germinating seeds per m², the row spacing was 12.5 cm and all cultivars were fertilised with nitrogen fertiliser (NH₄NO₃) in early spring using a range from 0–200 kg N ha⁻¹. There were 11 rates of nitrogen fertiliser, increasing the amounts by 20 kg N ha⁻¹. There were two 0 variants in order to establish the precise initial point of the regression equation.

Information about the weather was obtained from the Eerika Meteorological Station near Tartu. Protein content was measured in the Feed Laboratory of the Animal Breeding Institute of the Estonian Agricultural University by using Kjeltex's apparatus and Tecator AN assessment methods (Nx6.25). The falling number was determined at the Department of Field Crop Husbandry of the Estonian Agricultural University by the ICC Standard no 107 method. Correlation, dispersion and regression analyses were used in data processing.

RESULTS AND DISCUSSION

The weather conditions of the post-hibernation growth periods were very different in 1999–2001 (Fig. 1). The post-hibernation growth period of the experimental year 1998/1999 recorded little precipitation (2.1 times less than the long-term average

statistic). Since the air temperature was high at the same time, plants developed much faster, and the duration of the growth period in 1998/1999 was only 318 days (harvesting time 20 July 1999). On the other hand, in the post-hibernation period of 1999/2000 the total amount of precipitation was 1.2 times as high as the average of many years. Differences by month were even more remarkable. The total precipitation in July 2000 was 10 times higher than in July 1999 and twice as high as the average of many years. The quality of winter triticale grain was worst affected by the rains of July and August, accompanied by storm winds, which caused lodging and pre-harvest sprouting. Winter crops are normally in their dough developmental stage at this time in Estonia, (EC80-EC89; Tottman, 1987). The more there is rainfall, the longer becomes the seed-filling period (Fig. 2). The growth period in 1999/2000 was 350 days due to abundant precipitation (harvesting was done on 24 August, 2000). The weather conditions of the experimental year 2000/2001 were close to the average of many years. The length of winter triticale's growth period was 334 days (harvesting 7 August, 2001).

Fertilising with nitrogen after hibernation at the tillering stage in early spring increased the protein content of the seeds as well as the average of years and cultivars by up to 1.57% in dry matter. The protein content increased to a significant extent under the influence of the nitrogen fertiliser, mostly in the cultivars Modus, Tewo and Lasko (by 2.77, 1.89 and 1.74%, respectively, if we compare the N₀ and N₂₀₀ variants). The protein content of Dagro and Vision increased significantly up to the fertiliser doses of N₁₀₀ and N₁₆₀, respectively (Fig. 3). The use of high single nitrogen fertiliser levels to increase the protein content of the seeds is risky under Estonian conditions as it causes lodging and abundant pre-harvest sprouting.

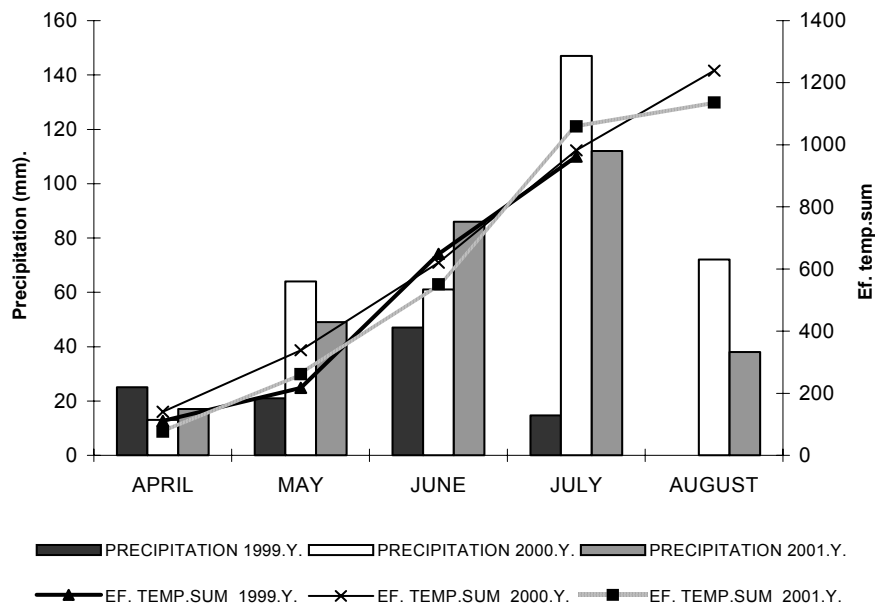


Fig. 1. Weather conditions of post-hibernation growth periods in 1999–2001. Effective temperature is temperature above 5°C.

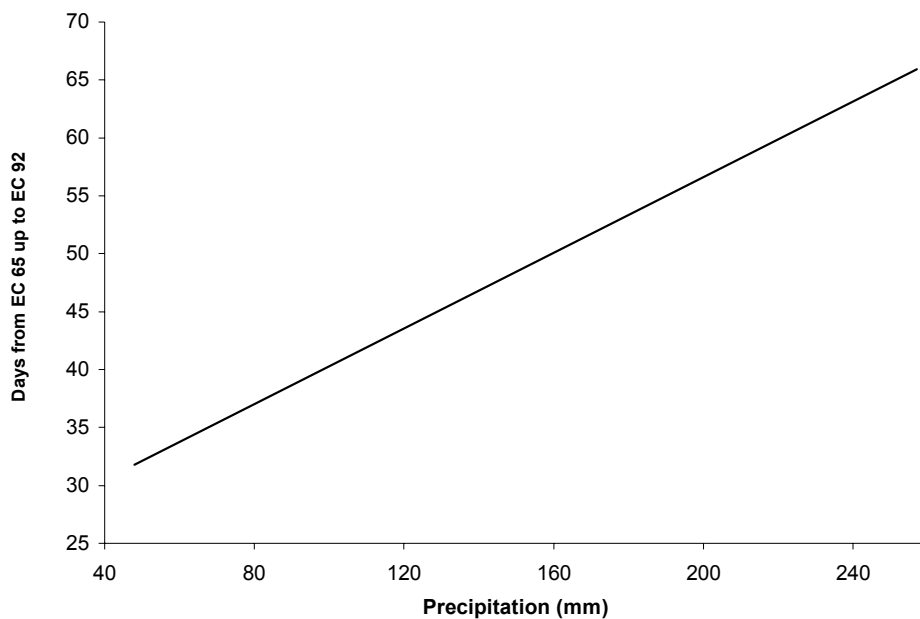


Fig. 2. Dependence of the length of seed-filling period on precipitation sums in 1999–2001; $r = 0.98$.

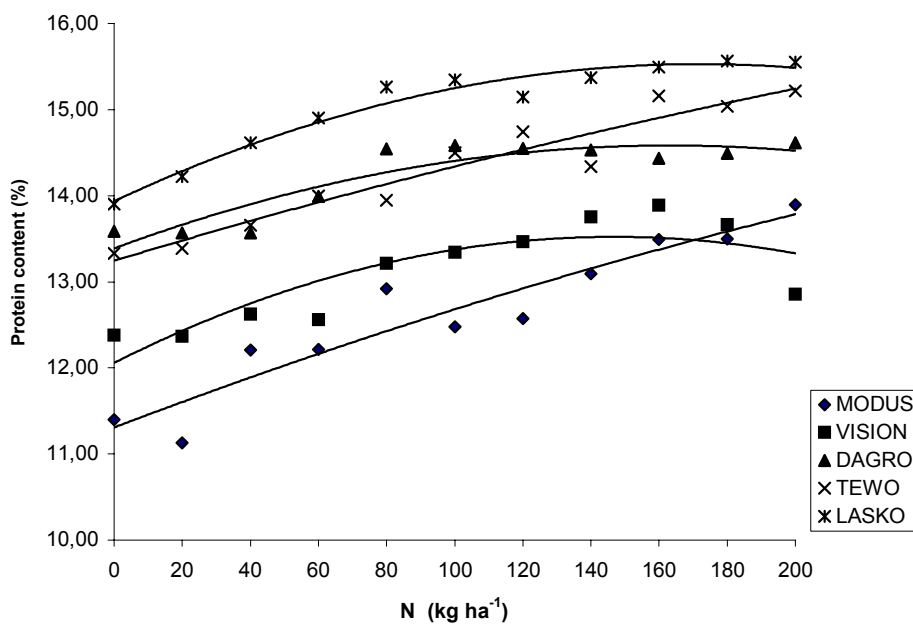


Fig. 3. Influence of nitrogen and cultivar on protein content (in DM) as the average of three years; $r_{\text{MODUS}} = 0.947^{***}$; $r_{\text{VISION}} = 0.867^{***}$; $r_{\text{DAGRO}} = 0.918^{***}$; $r_{\text{TEWO}} = 0.963^{***}$; $r_{\text{LASKO}} = 0.980^{***}$.

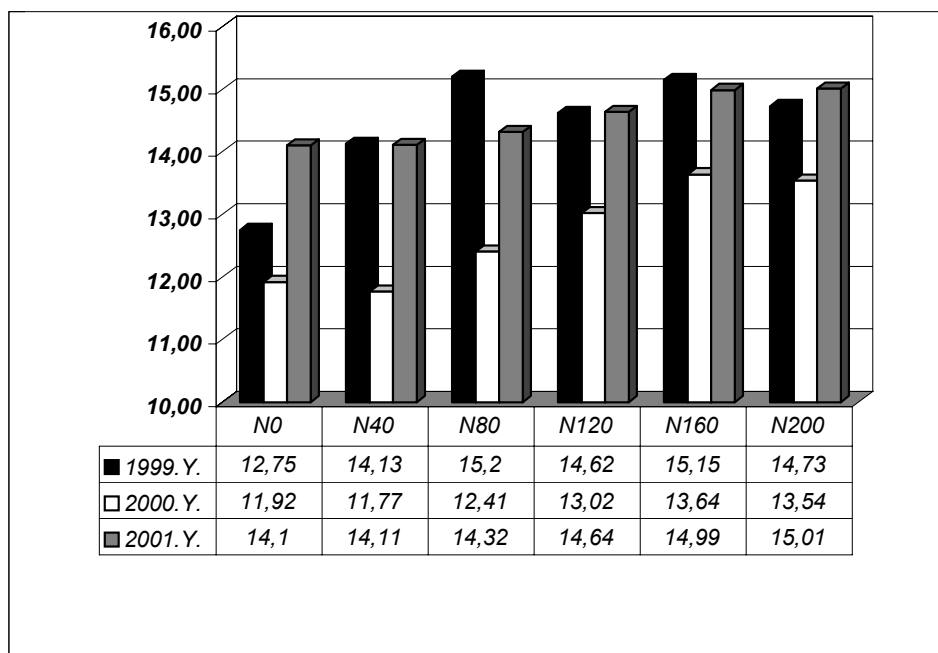


Fig. 4. Influence of nitrogen on the protein content as the average of cultivars; $r'99 = 0.92^{***}$; $r'00 = 0.97^{***}$; $r'01 = 0.98^{***}$; $n = 12$.

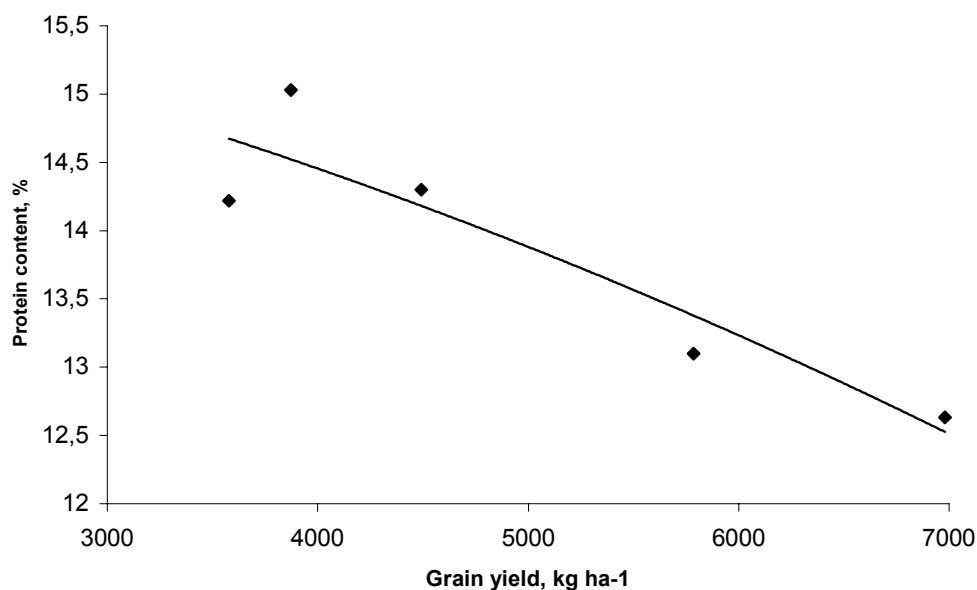


Fig. 5. Relationship between grain yield and protein content (in DM) as the average of three years; $r = 0.922^{**}$.

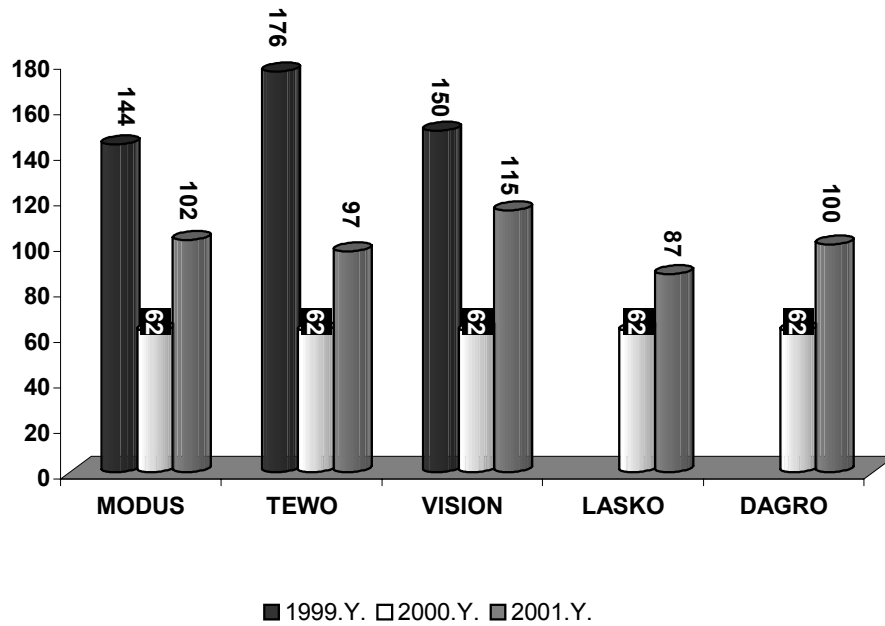


Fig. 6. Falling numbers of different winter triticale cultivars in 1999–2001.

The protein content of winter triticale strongly depended on the weather conditions during its growth time. The protein content was negatively correlated with the post-hibernation sums of precipitation and effective temperature ($r = -0.44^*$ and -0.49^{**} , respectively; $n = 33$). Protein levels depended most on the cultivar, less on the weather conditions of the growth year and least on the nitrogen fertiliser (Fig. 4; the determination indices of a dispersion analysis were 0.35, 0.32 and 0.14, respectively). This has also been confirmed by earlier studies (Lepajõe, 1984; Heger & Eggum, 1991).

The nitrogen fertiliser remarkably increased grain yield. However, as it was shown by previous research data (Bruckner et al., 1998; Simmonds, 1994; Fossati et al., 1993) and the results of our experiments, yield and protein levels are in negative correlation ($r = 0.92^*$; Fig. 5). As the average of three years, the cultivar with the highest grain yield was Modus (6981 kg ha^{-1}), followed by Vision (5786 kg ha^{-1}). At the same time, the protein content of these cultivars averaged over nitrogen backgrounds was 12.6 and 13.1%, respectively. The protein content of cultivars with smaller yields, such as Tewo, Lasko and Dagro (4491 , 3873 and 3579 kg ha^{-1} , respectively), as the average of the three years and N norms, was 14.3, 15.0 and 14.2%, respectively.

Since triticale is known as a crop with relatively high alfa-amylase activity (Sodkiewicz et al., 1996), the falling number is its significant quality indicator. Among important traits currently being considered, the Hagberg Falling Number plays a prominent role, as it is both an indicator of the pre-sprouting process and of high pre-

germination alfa-amylase activity potentially interacting with dough properties (Jestin & Bonhomme, 1996). Requirements for food crops with regard to the falling number (no less than 200 sec. for wheat and 100 sec. for rye; Tupits et al., 1999) are often too high for growing winter triticale in the local climate. The falling numbers were determined in the flours of different winter triticale cultivars. The falling number was most of all affected by the local weather conditions and then by the cultivar ($r = 0.733^{***}$; $r = 0.287^*$, respectively; $n = 48$). Due to very different weather conditions during the growth period, the figures were very different in different years (Fig. 6). In the year 2000, which was wet, the falling number in the flours of all winter triticale cultivars was just 62 sec., including the variants with no nitrogen fertiliser. In treatments with no or little nitrogen, invisible pre-harvest sprouting was reported. Plants getting higher N treatments were strongly lodged and the length of tillers grown from productive tiller ears was up to 10 cm. In droughty 1999, Tewo had the highest falling number (122–218 sec.). Unfortunately, it was not possible to determine the falling numbers in the seeds of Lasko and Dagro in 1999 but, according to the data of the Food Technology Institute of Tallinn Technical University, the falling number in Lasko flours was 245 sec. in 1997 (also a very dry year), which is a very good figure in our conditions. In 2001, when the weather conditions (the sum of precipitation and the sum of effective temperature) were close to the average of many years, the falling number, as the average for such nitrogen treatments and cultivars, was 100 sec. The effect of nitrogen fertiliser on the falling number was not significant.

An experiment carried out in Belgium (Derycke et al., 2002) concluded that the falling number had statistically significant interaction between a genotype and dry or humid storage conditions ($P < 0.001$). They found that they can divide cultivars – especially those stored under dry conditions – into two groups. The cultivars Phaedra, Triatlon, Janus, Babor, Ego, Ticino and Nemo showed high falling numbers (140–227 sec.), which changed during storage. The second group of cultivars (Boreas, Caio, Countri, Lupus, Modus, Vision, Tricolor and Trimaran) had constant and low falling numbers (62–80 sec.) and possibly a high tendency to sprouting. By the end of their experiment, the falling numbers showed that the dry condition resulted in the highest falling number, followed by the falling number of the variable humidity conditions and, finally, the constantly humid conditions resulted in the lowest falling number.

Introducing winter triticale in Estonia as a winter crop rich in essential amino acids (Fernandes-Figares et al., 2000) is likely. By using field experiments, the local researchers of winter triticale should select the most suitable cultivar for the local conditions. The primary selection criteria should be resistance to our winter cold, to pre-harvest sprouting, and a high protein content of the seeds. Of the cultivars used in our experiments, the most promising in the local climate was Tewo.

CONCLUSIONS

1. Winter triticale is a promising alternative feed crop in Estonia.
2. The primary criteria for selecting a suitable winter triticale cultivar for our unstable climatic conditions should be winterproofness, resistance to pre-harvest sprouting, shorter seed-filling period and a high protein content of the seed.

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